This is a current list of all FDA-approved radiopharmaceuticals. Nuclear medicine practitioners that receive radiopharmaceuticals that originate from sources other than the manufacturers listed in these tables may be using unapproved copies.

<table>
<thead>
<tr>
<th>Radiopharmaceutical</th>
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<th>Trade Names</th>
<th>Approved Indications in Adults (Pediatric use as noted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Carbon-11 choline</td>
<td>Various</td>
<td>–</td>
<td>Indicated for PET imaging of patients with suspected prostate cancer recurrence based upon elevated blood prostate specific antigen (PSA) levels following initial therapy and non-informative bone scintigraphy, computerized tomography (CT) or magnetic resonance imaging (MRI) to help identify potential sites of prostate cancer recurrence for subsequent histologic confirmation</td>
</tr>
<tr>
<td>2 Carbon-14 urea</td>
<td>Kimberly-Clark</td>
<td>PYtest</td>
<td>Detection of gastric urease as an aid in the diagnosis of H.pylori infection in the stomach</td>
</tr>
<tr>
<td>3 Fluorine-18 florbetaben</td>
<td>Piramal Imaging</td>
<td>Neuraceq™</td>
<td>Indicated for Positron Emission Tomography (PET) imaging of the brain to estimate β amyloid neuritic plaque density in adult patients with cognitive impairment who are being evaluated for Alzheimer’s disease (AD) or other causes of cognitive decline</td>
</tr>
<tr>
<td>4 Fluorine-18 florbetapir</td>
<td>Eli Lilly</td>
<td>Amyvid™</td>
<td>–</td>
</tr>
<tr>
<td>5 Fluorine-18 flucicovine</td>
<td>Blue Earth Diagnostics</td>
<td>Axumin™</td>
<td>A radioactive diagnostic agent indicated for positron emission tomography (PET) imaging in men with suspected prostate cancer recurrence based on elevated blood prostate specific antigen (PSA) levels following prior treatment</td>
</tr>
<tr>
<td>6 Fluorine-18 sodium fluoride</td>
<td>Various</td>
<td>–</td>
<td>PET bone imaging agent to delineate areas of altered osteogenesis</td>
</tr>
</tbody>
</table>

Package Inserts may be viewed at http://nps.cardinal.com/MSDSPI/Main.aspx
### Radiopharmaceuticals

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<th>Approved Indications in Adults (Pediatric use as noted)</th>
</tr>
</thead>
</table>
| 7 Fluorine-18 fludeoxyglucose | Various | – | As a PET imaging agent to:  
  • Assess abnormal glucose metabolism in oncology  
  • Assess myocardial hibernation  
  • Identify regions of abnormal glucose metabolism associated with foci of epileptic seizures |
| 8 Fluorine-18 flutemetamol | GE Healthcare | Vizamyl | Indicated for Positron Emission Tomography (PET) imaging of the brain to estimate β amyloid neuritic plaque density in adult patients with cognitive impairment who are being evaluated for Alzheimer’s disease (AD) or other causes of cognitive decline |
| 9 Gallium-67 citrate | Lantheus Medical Imaging | – | Useful to demonstrate the presence/extent of:  
  • Hodgkin’s disease  
  • Lymphoma  
  • Bronchogenic carcinoma  
  Aid in detecting some acute inflammatory lesions |
| 10 Gallium-68 dotatate | Advanced Accelerator Applications | NETSPOT™ | A radioactive diagnostic agent indicated for use with positron emission tomography (PET) for localization of somatostatin receptor positive neuroendocrine tumors (NETs) in adult and pediatric patients |
| 11 Indium-111 capromab pendetide | Aytu Pharmaceuticals | ProstaScint® |  
  • A diagnostic imaging agent in newly-diagnosed patients with biopsy-proven prostate cancer, thought to be clinically-localized after standard diagnostic evaluation (e.g. chest x-ray, bone scan, CT scan, or MRI), who are at high-risk for pelvic lymph node metastases  
  • A diagnostic imaging agent in post-prostatectomy patients with a rising PSA and a negative or equivocal standard metastatic evaluation in whom there is a high clinical suspicion of occult metastatic disease |
| 12 Indium-111 chloride | GE Healthcare | Indiclor™ | Indicated for radiolabeling:  
  • ProstaScint® used for in vivo diagnostic imaging procedures |
| 13 Indium-111 pentetate | GE Healthcare | – | For use in radionuclide cisternography |
| 14 Indium-111 oxyquinoline | GE Healthcare | – | Indicated for radiolabeling autologous leukocytes which may be used as an adjunct in the detection of inflammatory processes to which leukocytes migrate, such as those associated with abscesses or other infection |
| 15 Indium-111 pentetreotide | Mallinckrodt | Octreoscan™ | An agent for the scintigraphic localization of primary and metastatic neuroendocrine tumors bearing somatostatin receptors |
| 16 Iodine I-123 iobenguane | GE Healthcare | AdreView™ | Indicated for use in the detection of primary or metastatic pheochromocytoma or neuroblastoma as an adjunct to other diagnostic tests.  
  Indicated for scintigraphic assessment of sympathetic innervation of the myocardium by measurement of the heart to mediastinum (H/M) ratio of radioactivity uptake in patients with New York Heart Association (NYHA) class II or class III heart failure and left ventricular ejection fraction (LVEF) ≤ 35%. Among these patients, it may be used to help identify patients with lower one and two year mortality risks, as indicated by an H/M ratio ≥ 1.6. Limitations of Use: In patients with congestive heart failure, its utility has not been established for: selecting a therapeutic intervention or for monitoring the response to therapy; using the H/M ratio to identify a patient with a high risk for death. |

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Radiopharmaceuticals that may potentially have unapproved copies of FDA-approved commercially available radiopharmaceuticals in the marketplace.
<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>Iodine I-123 ioflupane</td>
<td>GE Healthcare</td>
<td>DaTscan™</td>
<td>Indicated for striatal dopamine transporter visualization using SPECT brain imaging to assist in the evaluation of adult patients with suspected Parkinsonian syndromes (PS) in whom it may help differentiate essential tremor due to PS (idiopathic Parkinson's disease, multiple system atrophy and progressive supranuclear palsy)</td>
</tr>
<tr>
<td>Iodine I-123 sodium iodide capsules</td>
<td>Cardinal Health</td>
<td>–</td>
<td>Indicated for use in the evaluation of thyroid:                                                                                     • Function</td>
</tr>
<tr>
<td></td>
<td>Mallinckrodt</td>
<td>–</td>
<td>• Morphology</td>
</tr>
<tr>
<td>Iodine I-125 human serum albumin</td>
<td>IsoTex Diagnostics</td>
<td>Jeanatope</td>
<td>Indicated for use in the determination of:                                                                                     • Total blood</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Plasma volume</td>
</tr>
<tr>
<td>Iodine I-125 iothalamate</td>
<td>IsoTex Diagnostics</td>
<td>Glofil-125</td>
<td>Indicated for evaluation of glomerular filtration</td>
</tr>
<tr>
<td>Iodine I-131 human serum albumin</td>
<td>IsoTex Diagnostics</td>
<td>Megatope</td>
<td>Indicated for use in determinations of:                                                                                     • Total blood and plasma volumes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cardiac output</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Cardiac and pulmonary blood volumes and circulation times</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Protein turnover studies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Heart and great vessel delineation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Localization of the placenta</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Localization of cerebral neoplasms</td>
</tr>
<tr>
<td>Iodine I-131 sodium iodide</td>
<td>DRAXIMAGE</td>
<td>HICON™</td>
<td>Diagnostic:                                                                                                                   • Performance of the radioactive iodide (RAI) uptake test to evaluate thyroid function</td>
</tr>
<tr>
<td></td>
<td>Mallinckrodt</td>
<td>–</td>
<td>• Localizing metastases associated with thyroid malignancies</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Therapeutic:                                                                                                                  • Treatment of hyperthyroidism</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Treatment of carcinoma of the thyroid</td>
</tr>
<tr>
<td>Molybdenum Mo-99 generator</td>
<td>GE Healthcare</td>
<td>DRYTEC™</td>
<td>Generation of Tc-99m sodium pertechnetate for administration or radiopharmaceutical preparation</td>
</tr>
<tr>
<td></td>
<td>Lantheus Medical Imaging</td>
<td>Technelite®</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mallinckrodt</td>
<td>Ultra-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>TechnneKow™ V4</td>
<td></td>
</tr>
<tr>
<td>Nitrogen-13 ammonia</td>
<td>Various</td>
<td>–</td>
<td>Indicated for diagnostic Positron Emission Tomography (PET) imaging of the myocardium under rest or pharmacologic stress conditions to evaluate myocardial perfusion in patients with suspected or existing coronary artery disease</td>
</tr>
<tr>
<td>Radium-223 dichloride</td>
<td>Bayer HealthCare Pharmaceuticls Inc.</td>
<td>Xofigo®</td>
<td>Indicated for the treatment of patients with castration-resistant prostate cancer, symptomatic bone metastases and no known visceral metastatic disease</td>
</tr>
<tr>
<td>Radiopharmaceutical</td>
<td>Manufacturer</td>
<td>Trade Names</td>
<td>Approved Indications in Adults (Pediatric use as noted)</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>------------------------------------------------------</td>
</tr>
<tr>
<td>Rubidium-82 chloride</td>
<td>Bracco Diagnostics</td>
<td>Cardiogen-82&lt;sup&gt;a&lt;/sup&gt;</td>
<td>PET myocardial perfusion agent that is useful in distinguishing normal from abnormal myocardium in patients with suspected myocardial infarction</td>
</tr>
<tr>
<td>Samarium-153 lexidronam</td>
<td>Lantheus Medical Imaging</td>
<td>Quadramet&lt;sup&gt;*&lt;/sup&gt;</td>
<td>Indicated for relief of pain in patients with confirmed osteoblastic metastatic bone lesions that enhance on radionuclide bone scan</td>
</tr>
<tr>
<td>Strontium-89 chloride</td>
<td>GE Healthcare</td>
<td>Metastron™</td>
<td>Indicated for the relief of bone pain in patients with painful skeletal metastases that have been confirmed prior to therapy</td>
</tr>
<tr>
<td>Technetium-99m bicisate</td>
<td>Lantheus Medical Imaging</td>
<td>Neurolite&lt;sup&gt;®&lt;/sup&gt;</td>
<td>SPECT imaging as an adjunct to conventional CT or MRI imaging in the localization of stroke in patients in whom stroke has already been diagnosed</td>
</tr>
<tr>
<td>Technetium-99m disofenin</td>
<td>Pharmalucence</td>
<td>Hepatolite&lt;sup&gt;®&lt;/sup&gt;</td>
<td>Diagnosis of acute cholecystitis as well as to rule out the occurrence of acute cholecystitis in suspected patients with right upper quadrant pain, fever, jaundice, right upper quadrant tenderness and mass or rebound tenderness, but not limited to these signs and symptoms</td>
</tr>
<tr>
<td>Technetium-99m exametazine</td>
<td>GE Healthcare</td>
<td>Ceretec™</td>
<td>• As an adjunct in the detection of altered regional cerebral perfusion in stroke • Leukocyte labeled scintigraphy as an adjunct in the localization of intra abdominal infection and inflammatory bowel disease</td>
</tr>
<tr>
<td>Technetium-99m macroaggregated albumin</td>
<td>DRAZIMAGE</td>
<td>–</td>
<td>• An adjunct in the evaluation of pulmonary perfusion (adult and pediatric) • Evaluation of peritoneo-venous (LaVeen) shunt patency</td>
</tr>
<tr>
<td>Technetium-99m mebrofenin</td>
<td>Bracco Diagnostics</td>
<td>Choletec®</td>
<td>As a hepatobiliary imaging agent</td>
</tr>
<tr>
<td>Technetium-99m medronate</td>
<td>DRAZIMAGE</td>
<td>MDP-25</td>
<td>As a bone imaging agent to delineate areas of altered osteogenesis</td>
</tr>
<tr>
<td>Technetium-99m mertiatide</td>
<td>Mallinckrodt</td>
<td>Technescan MAG3™</td>
<td>In patients &gt; 30 days of age as a renal imaging agent for use in the diagnosis of: • Congenital and acquired abnormalities • Renal failure • Urinary tract obstruction and calculi Diagnostic aid in providing: • Renal function • Split function • Renal angiograms • Renogram curves for whole kidney and renal cortex</td>
</tr>
<tr>
<td>Technetium-99m oxidonate</td>
<td>Mallinckrodt</td>
<td>Technescan&lt;sup&gt;®&lt;/sup&gt; HDP</td>
<td>As a bone imaging agent to delineate areas of altered osteogenesis (adult and pediatric use)</td>
</tr>
<tr>
<td>Technetium-99m pentetate</td>
<td>DRAZIMAGE</td>
<td>–</td>
<td>• Brain imaging • Kidney imaging: - To assess renal perfusion - To estimate glomerular filtration rate</td>
</tr>
</tbody>
</table>

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| 38 Technetium-99m pyrophosphate | Mallinckrodt | Technescan™ PYP™ | • As a bone imaging agent to delineate areas of altered osteogenesis  
• As a cardiac imaging agent used as an adjunct in the diagnosis of acute myocardial infarction  
• As a blood pool imaging agent useful for:  
  - Gated blood pool imaging  
  - Detection of sites of gastrointestinal bleeding |
|                     | Pharmalucence | –           |                                                      |
| 39 Technetium-99m red blood cells | Mallinckrodt | UltraTag™ | Tc99m-labeled red blood cells are used for:  
• Blood pool imaging including cardiac first pass and gated equilibrium imaging  
• Detection of sites of gastrointestinal bleeding |
| 40 Technetium-99m sestamibi | Cardinal Health | – | Myocardial perfusion agent that is indicated for:  
• Detecting coronary artery disease by localizing myocardial ischemia (reversible defects) and infarction (non-reversible defects)  
• Evaluating myocardial function  
• Developing information for use in patient management decisions  
• Planar breast imaging as a second line diagnostic drug after mammography to assist in the evaluation of breast lesions in patients with an abnormal mammogram or a palpable breast mass |
|                     | DRAXIMAGE | – |                                                      |
|                     | Lantheus Medical Imaging | Cardiolite® |                                                      |
|                     | Mallinckrodt | – |                                                      |
|                     | Pharmalucence | – |                                                      |
| 41 Technetium-99m sodium pertechnetate | GE Healthcare | – | • Brain Imaging (including cerebral radionuclide angiography)*  
• Thyroid Imaging*  
• Salivary Gland Imaging  
• Placenta Localization  
• Blood Pool Imaging (including radionuclide angiography)*  
• Urinary Bladder Imaging (direct isotopic cystography) for the detection of vesico-ureteral reflux*  
• Nasolacrimal Drainage System Imaging  
(*adult and pediatric use) |
|                     | Lantheus Medical Imaging | – |                                                      |
|                     | Mallinckrodt | – |                                                      |
| 42 Technetium-99m succimer | GE Healthcare | – | An aid in the scintigraphic evaluation of renal parenchymal disorders |
| 43 Technetium-99m sulfur colloid | Pharmalucence | – | • Imaging areas of functioning reticuloendothelial cells in the liver, spleen and bone marrow*  
• It is used orally for:  
  - Esophageal transit studies*  
  - Gastroesophageal reflux scintigraphy*  
  - Detection of pulmonary aspiration of gastric contents*  
• Aid in the evaluation of peritoneo-venous (LeVeen) shunt patency  
• To assist in the localization of lymph nodes draining a primary tumor in patients with breast cancer or malignant melanoma when used with a hand-held gamma counter  
(*adult and pediatric use) |
| 44 Technetium-99m tetrofosmin | GE Healthcare | Myoview™ | Myocardial perfusion agent that is indicated for:  
• Detecting coronary artery disease by localizing myocardial ischemia (reversible defects) and infarction (non-reversible defects)  
• The assessment of left ventricular function  
• (left ventricular ejection fraction and wall motion) |

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<tr>
<td>45 Technetium-99m tilmanocept</td>
<td>Navidea Biopharmaceuticals, Inc.</td>
<td>Lymphoseek*</td>
<td>Indicated with or without scintigraphic imaging for:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Lymphatic mapping using a handheld gamma counter to locate lymph nodes draining a primary tumor site in patients with solid tumors for which this procedure is a component of intraoperative management.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Guiding sentinel lymph node biopsy using a handheld gamma counter in patients with clinically node negative squamous cell carcinoma of the oral cavity, breast cancer or melanoma.</td>
</tr>
<tr>
<td>46 Thallium-201 chloride</td>
<td>GE Healthcare</td>
<td>–</td>
<td>• Useful in myocardial perfusion imaging for the diagnosis and localization of myocardial infarction</td>
</tr>
<tr>
<td></td>
<td>Lantheus Medical Imaging</td>
<td>–</td>
<td>• As an adjunct in the diagnosis of ischemic heart disease (atherosclerotic coronary artery disease)</td>
</tr>
<tr>
<td></td>
<td>Mallinckrodt</td>
<td>–</td>
<td>• Localization of sites of parathyroid hyperactivity in patients with elevated serum calcium and parathyroid hormone levels</td>
</tr>
<tr>
<td>47 Xenon-133 gas</td>
<td>Lantheus Medical Imaging</td>
<td>–</td>
<td>• The evaluation of pulmonary function and for imaging the lungs</td>
</tr>
<tr>
<td></td>
<td>Mallinckrodt</td>
<td></td>
<td>• Assessment of cerebral flow</td>
</tr>
<tr>
<td>48 Yttrium-90 chloride</td>
<td>Eckert &amp; Ziegler Nuclitec</td>
<td>–</td>
<td>Indicated for radiolabeling:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Zevalin* used for radioimmunotherapy procedures</td>
</tr>
<tr>
<td>49 Yttrium-90 ibritumomab tiuxetan</td>
<td>Spectrum Pharmaceuticals</td>
<td>Zevalin*</td>
<td>Indicated for the:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Treatment of relapsed or refractory, low-grade or follicular B-cell non-Hodgkin’s lymphoma (NHL)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Treatment of previously untreated follicular NHL in patients who achieve a partial or complete response to first-line chemotherapy</td>
</tr>
</tbody>
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Fludeoxyglucose F-18 Injection is indicated for positron emission tomography (PET) imaging in the following settings:

- Oncology: For assessment of abnormal glucose metabolism to assist in the evaluation of malignancy in patients with known or suspected abnormalities found by other testing modalities, or in patients with an existing diagnosis of cancer.
- Cardiology: For the identification of left ventricular myocardium with residual glucose metabolism and reversible loss of systolic function in patients with coronary artery disease and left ventricular dysfunction, when used together with myocardial perfusion imaging.
- Neurology: For the identification of regions of abnormal glucose metabolism associated with foci of epileptic seizures.

Screen for blood glucose abnormalities.

In the oncology and neurology settings, instruct patients to fast for 4 – 6 hours prior to the drug’s injection. Consider medical therapy and laboratory testing to assure at least two days of normoglycemia prior to the drug’s administration (5.2).

In the cardiology setting, administration of glucose-containing food or liquids (e.g., 50 – 75 grams) prior to the drug’s injection facilitates localization of cardiac ischemia (2.3).

Aseptically withdraw Fludeoxyglucose F-18 Injection from its container and administer by intravenous injection (2). The recommended dose:

- for adults is 5 – 10 mCi (185 – 370 MBq), in all indicated clinical settings (2.1).
- for pediatric patients is 2.6 mCi in the neurology setting (2.2).

Fludeoxyglucose F-18 Injection emits radiation. Use procedures to minimize radiation exposure. Screen for blood glucose abnormalities.

In the cardiology setting, administration of glucose-containing food or liquids (e.g., 50 – 75 grams) prior to the drug’s injection facilitates localization of cardiac ischemia (2.3).

Review the full prescribing information and 4.5 mg of sodium chloride in citrate buffer (10 mL vial: approximately 5.10 mL volume; 30 mL vial: approximately 10-30 mL volume) for intravenous administration (3).

Fludeoxyglucose F-18 Injection emits radiation. Use procedures to minimize radiation exposure.

<table>
<thead>
<tr>
<th>INDICATIONS AND USAGE</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>Oncology: For assessment of abnormal glucose metabolism to assist in the evaluation of malignancy in patients with known or suspected abnormalities found by other testing modalities, or in patients with an existing diagnosis of cancer.</td>
</tr>
<tr>
<td>Cardiology: For the identification of left ventricular myocardium with residual glucose metabolism and reversible loss of systolic function in patients with coronary artery disease and left ventricular dysfunction, when used together with myocardial perfusion imaging.</td>
</tr>
<tr>
<td>Neurology: For the identification of regions of abnormal glucose metabolism associated with foci of epileptic seizures.</td>
</tr>
</tbody>
</table>

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- Oncology: For assessment of abnormal glucose metabolism to assist in the evaluation of malignancy in patients with known or suspected abnormalities found by other testing modalities, or in patients with an existing diagnosis of cancer.
- Cardiology: For the identification of left ventricular myocardium with residual glucose metabolism and reversible loss of systolic function in patients with coronary artery disease and left ventricular dysfunction, when used together with myocardial perfusion imaging.
- Neurology: For the identification of regions of abnormal glucose metabolism associated with foci of epileptic seizures.

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In the cardiology setting, administration of glucose-containing food or liquids (e.g., 50 – 75 grams) prior to the drug’s injection facilitates localization of cardiac ischemia (2.3).

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- for adults is 5 – 10 mCi (185 – 370 MBq), in all indicated clinical settings (2.1).
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Table 1. Estimated Absorbed Radiation Doses (rem/mCi) After Intravenous Administration of Fluodeoxyglucose F-18 Injection

<table>
<thead>
<tr>
<th>Organ</th>
<th>Newborn (3.4 kg)</th>
<th>1-year old (9.8 kg)</th>
<th>5-year old (19 kg)</th>
<th>10-year old (32 kg)</th>
<th>15-year old (57 kg)</th>
<th>Adult (78 kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder wall*</td>
<td>4.3</td>
<td>1.7</td>
<td>0.95</td>
<td>0.60</td>
<td>0.40</td>
<td>0.32</td>
</tr>
<tr>
<td>Heart wall</td>
<td>2.4</td>
<td>1.2</td>
<td>0.70</td>
<td>0.44</td>
<td>0.29</td>
<td>0.22</td>
</tr>
<tr>
<td>Pancreas</td>
<td>2.2</td>
<td>0.68</td>
<td>0.33</td>
<td>0.25</td>
<td>0.13</td>
<td>0.096</td>
</tr>
<tr>
<td>Spleen</td>
<td>2.2</td>
<td>0.84</td>
<td>0.46</td>
<td>0.29</td>
<td>0.19</td>
<td>0.14</td>
</tr>
<tr>
<td>Lungs</td>
<td>0.65</td>
<td>0.38</td>
<td>0.20</td>
<td>0.13</td>
<td>0.092</td>
<td>0.064</td>
</tr>
<tr>
<td>Kidneys</td>
<td>0.81</td>
<td>0.34</td>
<td>0.19</td>
<td>0.13</td>
<td>0.089</td>
<td>0.074</td>
</tr>
<tr>
<td>Ovaries</td>
<td>0.80</td>
<td>0.8</td>
<td>0.19</td>
<td>0.11</td>
<td>0.058</td>
<td>0.053</td>
</tr>
<tr>
<td>Uterus</td>
<td>0.79</td>
<td>0.35</td>
<td>0.19</td>
<td>0.12</td>
<td>0.076</td>
<td>0.062</td>
</tr>
<tr>
<td>LLI wall*</td>
<td>0.69</td>
<td>0.28</td>
<td>0.15</td>
<td>0.097</td>
<td>0.060</td>
<td>0.051</td>
</tr>
<tr>
<td>Liver</td>
<td>0.69</td>
<td>0.31</td>
<td>0.17</td>
<td>0.11</td>
<td>0.076</td>
<td>0.058</td>
</tr>
<tr>
<td>Gallbladder wall*</td>
<td>0.69</td>
<td>0.26</td>
<td>0.14</td>
<td>0.093</td>
<td>0.059</td>
<td>0.049</td>
</tr>
<tr>
<td>Small intestine</td>
<td>0.68</td>
<td>0.29</td>
<td>0.15</td>
<td>0.096</td>
<td>0.060</td>
<td>0.047</td>
</tr>
<tr>
<td>LLI wall**</td>
<td>0.67</td>
<td>0.27</td>
<td>0.15</td>
<td>0.090</td>
<td>0.057</td>
<td>0.046</td>
</tr>
<tr>
<td>Stomach wall</td>
<td>0.65</td>
<td>0.27</td>
<td>0.14</td>
<td>0.089</td>
<td>0.057</td>
<td>0.047</td>
</tr>
<tr>
<td>Adrenals</td>
<td>0.65</td>
<td>0.28</td>
<td>0.15</td>
<td>0.095</td>
<td>0.061</td>
<td>0.048</td>
</tr>
<tr>
<td>Testes</td>
<td>0.64</td>
<td>0.27</td>
<td>0.14</td>
<td>0.085</td>
<td>0.052</td>
<td>0.041</td>
</tr>
<tr>
<td>Red marrow</td>
<td>0.62</td>
<td>0.26</td>
<td>0.14</td>
<td>0.089</td>
<td>0.057</td>
<td>0.047</td>
</tr>
<tr>
<td>Thymus</td>
<td>0.61</td>
<td>0.26</td>
<td>0.14</td>
<td>0.086</td>
<td>0.056</td>
<td>0.044</td>
</tr>
<tr>
<td>Thyroid</td>
<td>0.61</td>
<td>0.26</td>
<td>0.13</td>
<td>0.080</td>
<td>0.049</td>
<td>0.039</td>
</tr>
<tr>
<td>Muscle</td>
<td>0.58</td>
<td>0.25</td>
<td>0.13</td>
<td>0.078</td>
<td>0.049</td>
<td>0.039</td>
</tr>
<tr>
<td>Bone surface</td>
<td>0.57</td>
<td>0.24</td>
<td>0.12</td>
<td>0.079</td>
<td>0.052</td>
<td>0.041</td>
</tr>
<tr>
<td>Breast</td>
<td>0.54</td>
<td>0.22</td>
<td>0.11</td>
<td>0.068</td>
<td>0.043</td>
<td>0.034</td>
</tr>
<tr>
<td>Skin</td>
<td>0.49</td>
<td>0.20</td>
<td>0.10</td>
<td>0.060</td>
<td>0.037</td>
<td>0.030</td>
</tr>
<tr>
<td>Brain</td>
<td>0.29</td>
<td>0.13</td>
<td>0.09</td>
<td>0.078</td>
<td>0.072</td>
<td>0.070</td>
</tr>
<tr>
<td>Other tissues</td>
<td>0.59</td>
<td>0.25</td>
<td>0.13</td>
<td>0.083</td>
<td>0.052</td>
<td>0.042</td>
</tr>
<tr>
<td>ULI wall*</td>
<td>0.59</td>
<td>0.25</td>
<td>0.13</td>
<td>0.083</td>
<td>0.052</td>
<td>0.042</td>
</tr>
</tbody>
</table>

* MIRDose 2 software was used to calculate the radiation absorbed dose. Assumptions on the biodistribution based on data from Gallagher et al.1 and Jones et al.2

1 The dynamic bladder model with a uniform voiding frequency of 1.5 hours was used.

2 The safety and effectiveness of Fluodeoxyglucose F-18 Injection in pediatric patients with epilepsy is established on the basis of studies in adult and pediatric patients. In pediatric patients with epilepsy, the recommended dose is 2.6 mCi. The optimal dose adjustment on the basis of body size or weight has not been determined.

For use in correcting for physical decay of this radionuclide, the fractions remaining at selected intervals after calibration are shown in Table 4.
12 CLINICAL PHARMACOLOGY

12.1 Mechanism of Action
Fludeoxyglucose F-18 is a glucose analog that concentrates in cells that rely upon glucose as an energy source, or in cells whose dependence on glucose increases under pathophysiological conditions. Fludeoxyglucose F-18 is taken up by the cell through the glucose transporter proteins and is phosphorylated within the cell to [\(^{18}\)F]FDG-6-phosphate by the enzyme hexokinase. Once phosphorylated it cannot exit until it is dephosphorylated by glucose-6-phosphatase. Therefore, within a given tissue or physiological process, the retention and clearance of Fludeoxyglucose F-18 reflect a balance involving glucose transporter, hexokinase and glucose-6-phosphatase activities. When allowance is made for the kinetic differences between glucose and Fludeoxyglucose F-18 transport and phosphorylation (expressed as the "lumped constant" ratio), Fludeoxyglucose F-18 is used to assess glucose metabolism.

In comparison to background activity of the specific organ or tissue type, regions of decreased or absent uptake of Fludeoxyglucose F-18 reflect the decrease or absence of glucose metabolism. Regions of increased uptake of Fludeoxyglucose F-18 reflect greater than normal rates of glucose metabolism.

12.2 Pharmacodynamics
Fludeoxyglucose F-18 Injection is rapidly distributed to all organs of the body after intravenous administration. After background clearance of Fludeoxyglucose F-18 Injection, optimal PET imaging is generally achieved between 30 to 40 minutes after administration. In cancer, the cells are generally characterized by enhanced glucose metabolism partially due to (1) an increase in activity of glucose transporters, (2) an increased rate of phosphorylation activity, (3) a reduction of phosphatase activity, or (4) a dynamic alteration in the balance among all these processes. However, glucose metabolism of cancer as reflected by Fludeoxyglucose F-18 accumulation shows considerable variability. Depending on tumor type, stage, and location, Fludeoxyglucose F-18 accumulation may be increased, normal, or decreased. Also, inflammatory cells can have the same variability of uptake of Fludeoxyglucose F-18.

In the heart, under normal aerobic conditions, the myocardium meets the bulk of its energy requirements by oxidizing free fatty acids. Most of the exogenous glucose takes up by the myocardy is converted into glycolgen. However, under ischemic conditions, the oxidation of free fatty acids decreases, exogenous glucose becomes the preferred myocardial substrate, glycoalysis is stimulated, and glucose taken up by the myocyte is metabolized immediately instead of being converted into glycolgen. Under these conditions, phosphorylated Fludeoxyglucose F-18 accumulates in the myocyte and can be detected with PET imaging.

In the brain, cells normally rely on aerobic metabolism. In epilepsy, the glucose metabolism varies. Generally, during a seizure, glucose metabolism increases. Interictally, the seizure focus tends to be hypometabolic.

13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility
Animal studies have not been performed to evaluate the Fludeoxyglucose F-18 Injection carcinogenic potential, mutagenic potential or effects on fertility.
Sodium Iodide I 123
Diagnostic-Capsules for Oral Administration

DESCRIPTION
Sodium Iodide I 123 (Na 123 I) for diagnostic use is supplied in capsules for oral administration. The capsules are available in strengths of 3.7, 7.4, and 14.8 microcuries (uCi) (100, 200, and 400 uCi) I 123 at time of calibration. Each capsule contains 3.38 microgram of Sodium Iodide as a stabilizer.

The radionuclidic composition at calibration is not less than 97.0 percent I 123, not more than 2.9 percent I 125 and not more than 0.1 percent all others (I 121 or Te 121). The radionuclidic composition at expiration time is not less than 87.2 percent I 123, not more than 12.4 percent I 125 and not more than 0.4 percent all others. The ratio of the concentration of I 123 and I 125 changes with time. Graph 1 shows the maximum concentration of each as a function of time.

Graph 1
Radionuclidic Concentration of I 123 and I 125

PHYSICAL CHARACTERISTICS
Sodium Iodide I 123 decays by electron capture with a physical half-life of 13.2 hours. The photon that is useful for detection and imaging studies is listed in Table 1.

Table 1
Principal Radiation Emission Data

<table>
<thead>
<tr>
<th>Radiation</th>
<th>Mean % Disintegration</th>
<th>Mean Energy (keV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gamma-2</td>
<td>83.4</td>
<td>159</td>
</tr>
</tbody>
</table>

*Kocher, David C., Radioactive Decay Data Tables, DOE/TIC-11026, 122, (1981)

EXTERNAL RADIATION
The specific gamma ray constant for I 123 is 1.66 r/hr-mCi at 1 cm. The first half value thickness of lead (Pb) for I 123 is 0.005 cm. A range of values for the relative attenuation of the radiation emitted by the radionuclide that results from the interposition of various thicknesses of Pb is shown in Table 2. For example, the use of 1.63 cm of lead will decrease the external radiation exposure by a factor of about 1,000.

<table>
<thead>
<tr>
<th>Shield Thickness (Pb), cm.</th>
<th>Coefficient of Attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.036</td>
<td>0.5</td>
</tr>
<tr>
<td>0.120</td>
<td>10'</td>
</tr>
<tr>
<td>0.240</td>
<td>10'</td>
</tr>
<tr>
<td>0.358</td>
<td>10'</td>
</tr>
<tr>
<td>0.477</td>
<td>10'</td>
</tr>
</tbody>
</table>


Note that these estimates of attenuation do not take into consideration the presence of contaminants.

To correct for physical decay of I 123, the fractions that remain at selected intervals after the time of calibration are shown in Table 3.

Table 2
Radiation Attenuation by Lead Shielding

<table>
<thead>
<tr>
<th>Shield Thickness (Pb), cm.</th>
<th>Coefficient of Attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.036</td>
<td>0.5</td>
</tr>
<tr>
<td>0.120</td>
<td>10'</td>
</tr>
<tr>
<td>0.240</td>
<td>10'</td>
</tr>
<tr>
<td>0.358</td>
<td>10'</td>
</tr>
<tr>
<td>0.477</td>
<td>10'</td>
</tr>
</tbody>
</table>


Table 3
Sodium Iodide I 123 Decay Chart: Half-Life 13.2 Hours

<table>
<thead>
<tr>
<th>Hours</th>
<th>Fraction Remaining</th>
<th>Hours</th>
<th>Fraction Remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>0'</td>
<td>1.000</td>
<td>18</td>
<td>0.389</td>
</tr>
<tr>
<td>3</td>
<td>0.854</td>
<td>21</td>
<td>0.332</td>
</tr>
<tr>
<td>6</td>
<td>0.730</td>
<td>24</td>
<td>0.284</td>
</tr>
<tr>
<td>9</td>
<td>0.623</td>
<td>27</td>
<td>0.242</td>
</tr>
<tr>
<td>12</td>
<td>0.536</td>
<td>30</td>
<td>0.207</td>
</tr>
<tr>
<td>15</td>
<td>0.457</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Time of Calibration

CLINICAL PHARMACOLOGY
Sodium iodide I 123 is readily absorbed from the upper gastrointestinal tract. Following absorption, the iodide is distributed primarily within the extracellular fluid of the body. It is trapped and organically bound by the thyroid and concentrated by the stomach, choroid plexus and salivary glands. It is excreted by the kidneys.

The fraction of the administered dose which is accumulated in the thyroid gland may be a measure of thyroid function in the absence of unusually high or low iodine intake or administration of certain drugs which influence iodine accumulation by the thyroid gland. Accordingly, the patient should be questioned carefully regarding previous medication and/or procedures involving radiographic media. Normal subjects can accumulate approximately 10-50% of the administered iodine dose in the thyroid gland, however, the normal and abnormal ranges are established by individual physician's criteria. The mapping (imaging) of Sodium Iodide I 123 distribution in the thyroid gland may provide useful information concerning thyroid anatomy and definition of normal and/or abnormal functioning of tissue within the gland.

INDICATION AND USE
Administration of Sodium iodide I 123 is indicated as a diagnostic procedure to be used in evaluating thyroid function and/or morphology.

CONTRAINDICATIONS
To date there are no known contraindications to the use of Sodium Iodide I 123 capsules.

WARNINGS
Females of childbearing age and children under 18 should not be studied unless the benefits anticipated from the performance of the test outweigh the possible risk of exposure to the amount of ionizing radiation associated with the test.
PRECAUTIONS

General
The contents of the capsule are radioactive. Adequate shielding of the preparation must be maintained at all times.

Do not use after the expiration time and date (30 hours after calibration time) stated on the label.

The prescribed Sodium Iodide 123 dose should be administered as soon as practical from the time of receipt of product (i.e., as close to calibration time as possible) in order to minimize the fraction of radiation exposure due to relative increase of radionuclide contaminants with time.

Sodium Iodide 123, as well as other radioactive drugs, must be handled with care and appropriate safety measures should be used to minimize radiation exposure to clinical personnel. Care should also be taken to minimize radiation exposure to the patient consistent with proper patient management.

Radiopharmaceuticals should be used only by physicians who are qualified by training and experience in the safe use and handling of radionuclides and whose experience and training have been approved by the appropriate government agency authorized to license the use of radionuclides.

Carcinogenesis, Mutagenesis, Impairment of Fertility
No long-term animal studies have been performed to evaluate carcinogenic potential, mutagenic potential, or whether Sodium Iodide 123 affects fertility in males or females.

Pregnancy Category C
Animal reproduction studies have not been conducted with this drug. It is also not known whether Sodium Iodide 123 can cause fetal harm when administered to a pregnant woman or can affect reproductive capacity. Sodium Iodide 123 should be given to a pregnant woman only if clearly needed.

Ideally examinations using radiopharmaceuticals, especially those elective in nature, in women of childbearing capacity should be performed during the first few (approximately ten) days following the onset of menses.

Nursing Mothers
Since I 123 is excreted in human milk, formula-feeding should be substituted for breast-feeding if the agent must be administered to the mother during lactation.

Pediatric Use
Safety and effectiveness in children have not been established.

ADVERSE REACTIONS
Although rare, reactions associated with the administration of Sodium iodide isotopes for diagnostic use include, in decreasing order of frequency, nausea, vomiting, chest pain, tachycardia, itching skin, rash and hives.

RADIATION DOSIMETRY
The estimated absorbed radiation doses to several organs of an average patient (70 kg) from oral administration of the maximum dose of 14.8 MBq (400 uCi) of I 123 are shown in Table 4 for thyroid uptakes of 5, 15, and 25%. For comparison at these three values of thyroid uptake, the estimated radiation doses from doses of 3.7 MBq (100 uCi) I 131, also used as thyroid imaging agent, are also included.

<table>
<thead>
<tr>
<th>Target Organ Uptake (%)</th>
<th>Maximum Thyroid Dose Absorbed</th>
<th>Thyroid</th>
<th>Liver</th>
<th>Red Blood Cells</th>
<th>Small Intestine</th>
<th>Stomach</th>
<th>Bladder</th>
<th>Kidney</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>15</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>25</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target Organ Uptake (%)</th>
<th>Maximum Thyroid Dose Absorbed</th>
<th>Thyroid</th>
<th>Liver</th>
<th>Red Blood Cells</th>
<th>Small Intestine</th>
<th>Stomach</th>
<th>Bladder</th>
<th>Kidney</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>15</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>25</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Target Organ Uptake (%)</th>
<th>Maximum Thyroid Dose Absorbed</th>
<th>Thyroid</th>
<th>Liver</th>
<th>Red Blood Cells</th>
<th>Small Intestine</th>
<th>Stomach</th>
<th>Bladder</th>
<th>Kidney</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>15</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
<tr>
<td>25</td>
<td>14.8 MBq (400 uCi)</td>
<td>75</td>
<td>230</td>
<td>0.16</td>
<td>0.85</td>
<td>0.27</td>
<td>0.09</td>
<td>1.0</td>
<td>1.7</td>
</tr>
</tbody>
</table>

HOW SUPPLIED
Sodium Iodide 123 is supplied as capsules for oral administration in strengths of 3.7 MBq (100 uCi), 7.4 MBq (200 uCi) and 14.8 MBq (400 uCi) at time of calibration. Each gelatin capsule contains 0.45 - 0.65 mg of sucrose. The capsules are packaged in plastic vials containing either one or five capsules of a single strength per vial. The plastic vial is packaged in a lead shield with a label identical to that applied to the plastic vial. A package insert is supplied with each lead shield.

The I (iodine) content for a 100 uCi capsule is 5.2 ng and the I content for a 200 uCi capsule is 10.4 ng. The I content for a 400uCi capsule is 20.8 ng at TOC.

Dispense and preserve capsules in well-closed containers that are adequately shielded. Store at room temperature, below 68°F.

The contents of the capsules are radioactive. Adequate shielding and handling precautions must be maintained.

CardinalHealth

Denver, CO 80211 (303) 343-6800

Sodium Iodide I 123
1-220-15 Printed in U.S.A.

THIS PACKAGE INSERT ISSUED NOVEMBER 2007
The radiated absorbed doses in rem/mCi are shown in Table 1. These estimates are calculated from the myocardiun under rest or pharmacologic stress conditions to evaluate myocardial perfusion in patients with suspected or existing coronary artery disease (1).

2.3 Patient Preparation

- Aseptically withdraw Ammonia N-13 Injection, USP from its container and administer 10-20 mCi (0.368 – 0.736 GBq) as a bolus through a catheter inserted into a large peripheral vein.
- Start imaging 3 minutes after the injection and acquire images for a total of 10-20 minutes.

Stress Imaging Study (2.2):

- If a rest imaging study is performed, begin the stress imaging study 40 minutes or more after the first Ammonia N-13 Injection, USP to allow sufficient isotope decay.
- Administer a pharmacologic stress-inducing drug in accordance with its labeling.
- Aseptically withdraw Ammonia N-13 Injection, USP from its container and administer 10-20 mCi (0.368 – 0.736 GBq) of Ammonia N-13 Injection, USP as a bolus at 8 minutes after the administration of the pharmacologic stress-inducing drug.
- Start imaging 3 minutes after the Ammonia N-13 Injection, USP and acquire images for a total of 10-20 minutes.

Patient Preparation (2.3):

- To increase renal clearance of radioactivity and to minimize radiation dose to the bladder, hydrate the patient before the procedure and encourage voiding as soon as each image acquisition is completed and as often as possible thereafter for at least one hour.

### Table 1: N-13 Absorbed Radiation Dose Per Unit Activity (rem/mCi) for Adults and Pediatric Groups

<table>
<thead>
<tr>
<th>Organ</th>
<th>Adult (15-year-old)</th>
<th>15-year-old</th>
<th>16-year-old</th>
<th>5-year-old</th>
<th>6-year-old</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adrenals</td>
<td>0.0085</td>
<td>0.0085</td>
<td>0.0085</td>
<td>0.0085</td>
<td>0.0085</td>
</tr>
<tr>
<td>Bladder wall</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
<td>0.091</td>
</tr>
<tr>
<td>Bone surfaces</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
<td>0.005</td>
</tr>
<tr>
<td>Brain</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
<td>0.016</td>
</tr>
<tr>
<td>Breast</td>
<td>0.0067</td>
<td>0.0067</td>
<td>0.0067</td>
<td>0.0067</td>
<td>0.0067</td>
</tr>
<tr>
<td>Stomach wall</td>
<td>0.0065</td>
<td>0.0065</td>
<td>0.0065</td>
<td>0.0065</td>
<td>0.0065</td>
</tr>
<tr>
<td>Small intestine</td>
<td>0.0081</td>
<td>0.0081</td>
<td>0.0081</td>
<td>0.0081</td>
<td>0.0081</td>
</tr>
</tbody>
</table>

### 2.4 Radiation Dosimetry

Glass vial containing 0.138-1.387 GBq (3.57-37.5 mCi/mL) of Ammonia N-13 Injection, USP in aqueous 0.9 % sodium chloride solution (approximately 8 mL to 10 mL volume). (3).

### DOSAGE FORMS AND STRENGTHS

Glass vial containing 0.138-1.387 GBq (3.57-37.5 mCi/mL) of Ammonia N-13 Injection, USP in aqueous 0.9 % sodium chloride solution (approximately 8 mL to 10 mL volume). (3).

### CONTRAINDICATIONS

None

### WARNINGS AND PRECAUTIONS

Ammonia N-13 Injection, USP may increase the risk of cancer. Use the smallest dose necessary for imaging and ensure safe handling to protect the patient, healthcare worker (5).

### ADVERSE REACTIONS

No adverse reactions have been reported for Ammonia N-13 Injection, USP based on a review of the published literature, publicly available reference sources, and adverse drug reaction reporting system (6).

To report SUSPECTED ADVERSE REACTIONS, contact Cardinal Health at 1-800-618-2768 or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch

### USE IN SPECIFIC POPULATIONS

- It is not known whether this drug is excreted in human milk. Alternatives to breastfeeding (e.g. using stored breast milk or infant formula) should be used for 2 hours (>10 half-lives of radioactive decay for N-13 isotope) after administration of Ammonia N-13 Injection, USP (8.3).
- The safety and effectiveness of Ammonia N-13 Injection, USP has been established in pediatric patients (8.4).

See 17 for PATIENT COUNSELING INFORMATION.

Revised: 12/2015

### USE IN SPECIFIC POPULATIONS

- Pregnancy
- Nursing Mothers
- Pediatric Use

### FULL PRESCRIBING INFORMATION: CONTENTS

1 INDICATIONS AND USAGE

Ammonia N-13 Injection, USP is indicated for diagnostic Positron Emission Tomography (PET) imaging of the myocardium under rest or pharmacologic stress conditions to evaluate myocardial perfusion in patients with suspected or existing coronary artery disease.

2 DOSAGE AND ADMINISTRATION

2.1 Rest Imaging Study

- Aseptically withdraw Ammonia N-13 Injection, USP from its container and administer 10-20 mCi (0.368 – 0.736 GBq) of Ammonia N-13 Injection, USP as a bolus at 8 minutes after the administration of the pharmacologic stress-inducing drug.
- Start imaging 3 minutes after the injection and acquire images for a total of 10-20 minutes.

2.2 Stress Imaging Study

- If a rest imaging study is performed, begin the stress imaging study 40 minutes or more after the first Ammonia N-13 Injection, USP to allow sufficient isotope decay.
- Administer a pharmacologic stress-inducing drug in accordance with its labeling.
- Aseptically withdraw Ammonia N-13 Injection, USP from its container and administer 10-20 mCi (0.368 – 0.736 GBq) of Ammonia N-13 Injection, USP as a bolus at 8 minutes after the administration of the pharmacologic stress-inducing drug.
- Start imaging 3 minutes after the Ammonia N-13 Injection, USP and acquire images for a total of 10-20 minutes.

2.3 Patient Preparation

- To increase renal clearance of radioactivity and to minimize radiation dose to the bladder, hydrate the patient before the procedure and encourage voiding as soon as each image acquisition is completed and as often as possible thereafter for at least one hour.

### FULL PRESCRIBING INFORMATION

1 INDICATIONS AND USAGE

Ammonia N-13 Injection, USP is indicated for diagnostic Positron Emission Tomography (PET) imaging of the myocardium under rest or pharmacologic stress conditions to evaluate myocardial perfusion in patients with suspected or existing coronary artery disease.

2 DOSAGE AND ADMINISTRATION

2.1 Rest Imaging Study

- Aseptically withdraw Ammonia N-13 Injection, USP from its container and administer 10-20 mCi (0.368 – 0.736 GBq) as a bolus through a catheter inserted into a large peripheral vein.
- Start imaging 3 minutes after the injection and acquire images for a total of 10-20 minutes.

Stress Imaging Study (2.2):

- If a rest imaging study is performed, begin the stress imaging study 40 minutes or more after the first Ammonia N-13 Injection, USP to allow sufficient isotope decay.
- Administer a pharmacologic stress-inducing drug in accordance with its labeling.
- Aseptically withdraw Ammonia N-13 Injection, USP from its container and administer 10-20 mCi (0.368 – 0.736 GBq) of Ammonia N-13 Injection, USP as a bolus at 8 minutes after the administration of the pharmacologic stress-inducing drug.
- Start imaging 3 minutes after the Ammonia N-13 Injection, USP and acquire images for a total of 10-20 minutes.

Patient Preparation (2.3):

- To increase renal clearance of radioactivity and to minimize radiation dose to the bladder, hydrate the patient before the procedure and encourage voiding as soon as each image acquisition is completed and as often as possible thereafter for at least one hour.

### 2.4 Radiation Dosimetry

Glass vial containing 0.138-1.387 GBq (3.57-37.5 mCi/mL) of Ammonia N-13 Injection, USP in aqueous 0.9 % sodium chloride solution (approximately 8 mL to 10 mL volume). (3).

### CONTRAINDICATIONS

None

### WARNINGS AND PRECAUTIONS

Ammonia N-13 Injection, USP may increase the risk of cancer. Use the smallest dose necessary for imaging and ensure safe handling to protect the patient, healthcare worker (5).

### ADVERSE REACTIONS

No adverse reactions have been reported for Ammonia N-13 Injection, USP based on a review of the published literature, publicly available reference sources, and adverse drug reaction reporting system (6).

To report SUSPECTED ADVERSE REACTIONS, contact Cardinal Health at 1-800-618-2768 or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch

### USE IN SPECIFIC POPULATIONS

- Pregnancy
- Nursing Mothers
- Pediatric Use

### 11 DESCRIPTION

11.1 Chemical Characteristics

11.2 Physical Characteristics

12 CLINICAL PHARMACOLOGY

12.1 Mechanism of Action

12.2 Pharmacodynamics

12.3 Pharmacokinetics

13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

14 CLINICAL STUDIES

15 REFERENCES

17 PATIENT COUNSELING INFORMATION

See 17 for PATIENT COUNSELING INFORMATION.

Revised: 12/2015

### 11 DESCRIPTION

11.1 Chemical Characteristics

11.2 Physical Characteristics

12 CLINICAL PHARMACOLOGY

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13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

14 CLINICAL STUDIES

15 REFERENCES

17 PATIENT COUNSELING INFORMATION

See 17 for PATIENT COUNSELING INFORMATION.

Revised: 12/2015
5 WARNINGS AND PRECAUTIONS

5.1 Radiation Risks
Ammonia N-13 Injection, USP may increase the risk of cancer. Use the smallest dose necessary for imaging and ensure safe handling to protect the patient and health care worker [see Dosage and Administration (2.4)].

6 ADVERSE REACTIONS
No adverse reactions have been reported for Ammonia N-13 Injection, USP based on a review of the published literature, publicly available reference sources, and adverse drug reaction reporting systems. However, the completeness of these sources is not known.

7 DRUG INTERACTIONS
The possibility of interactions of Ammonia N-13 Injection, USP with other drugs taken by patients undergoing PET imaging has not been studied.

8 USE IN SPECIFIC POPULATIONS

8.1 Pregnancy
Pregnancy Category C
Animal reproduction studies have not been conducted with Ammonia N-13 Injection, USP. It is also not known whether Ammonia N-13 Injection, USP can cause fetal harm when administered to a pregnant woman or can affect reproduction capacity. Ammonia N-13 Injection, USP should be given to a pregnant woman only if clearly needed.

8.3 Nursing Mothers
It is not known whether this drug is excreted in human milk. Because many drugs are excreted in human milk and because of the potential for radiation exposure to nursing infants from Ammonia N-13 Injection, USP, use alternative infant nutrition sources (e.g., breast milk or infant formula) for 2 hours after 1/10 half-lives of radioactive decay for N-13 (isotope) after administration of the drug or avoid use of the drug, taking into account the importance of the drug to the mother.

8.4 Pediatric Use
The safety and effectiveness of Ammonia N-13 Injection, USP has been established in pediatric patients based on known metabolism of ammonia, radiation dosimetry in the pediatric population, and clinical studies in adults [see Dosage and Administration (2.4)].

11 DESCRIPTION

11.1 Chemical Characteristics
Ammonia N-13 Injection, USP is a position emitting radiopharmaceutical that is used for diagnostic purposes in conjunction with positron emission tomography (PET) imaging. The active ingredient, [13N] ammonia, has the molecular formula of 13NH3 with a molecular weight of 16.02, and has the following chemical structure:

\[
\begin{align*}
N & \quad 13N \\
H & \quad 3H
\end{align*}
\]

Ammonia N-13 Injection, USP is provided as a ready to use sterile, pyrogen-free, clear and colorless solution.

11.2 Physical Characteristics
Nitrogen N-13 decays by emitting positron to Carbon C-13 (stable) and has a physical half-life of 9.96 minutes. The principal photons useful for imaging are the dual 511 keV gamma photons that are produced and emitted simultaneously in opposite direction at the point of interaction (see Table 2).

Table 2: Principal Radiation Emission Data for Nitrogen 13

<table>
<thead>
<tr>
<th>Radiation/Emission</th>
<th>% Per Disintegration</th>
<th>Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photon(eV)</td>
<td>100</td>
<td>1907 keV (Max.)</td>
</tr>
<tr>
<td>Gamma(±)</td>
<td></td>
<td>511 keV</td>
</tr>
</tbody>
</table>

a) Produced by positron annihilation.

The specific gamma ray constant (point source air kerma coefficient) for nitrogen N-13 is 5.89 R/hr/mCi (1.39 x 10^-5 Gy/hr/mCi) at 1 cm. The half-value layer (HVL) of lead (Pb) for 511 keV photons is 4 mm, or 2.9 mm tungsten (W) alloy. Selected coefficients of attenuation are listed in Table 3 as a function of lead thickness. For example, the use of 39 mm thickness of lead or 28 mm of tungsten alloy will attenuate the external radiation by a factor of about 1000.

Table 3: Radiation Attenuation of 511 keV Photons by Lead (Pb) Shielding

<table>
<thead>
<tr>
<th>Shield Thickness (Pb) mm</th>
<th>Shiel Thickness (W) mm</th>
<th>Coefficient of Attenuation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>0.88</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>0.60</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0.40</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>0.10</td>
</tr>
<tr>
<td>6</td>
<td>7</td>
<td>0.01</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 4 lists fractions remaining at selected time intervals from the calibration time. This information may be used to correct for physical decay of the radionuclide.

Table 4: Physical Decay Chart for Nitrogen 13

<table>
<thead>
<tr>
<th>Time (minutes)</th>
<th>Fraction Remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.0000</td>
</tr>
<tr>
<td>5</td>
<td>0.9006</td>
</tr>
<tr>
<td>10</td>
<td>0.9099</td>
</tr>
<tr>
<td>15</td>
<td>0.9532</td>
</tr>
<tr>
<td>20</td>
<td>0.9993</td>
</tr>
<tr>
<td>30</td>
<td>0.9976</td>
</tr>
<tr>
<td>60</td>
<td>0.9963</td>
</tr>
</tbody>
</table>

a) calibration time

12.2 Pharmacodynamics
Following intravenous injection, ammonia N-13 enters the myocardium through the coronary arteries. The PET technique measures myocardial blood flow based on the assumption of a three-compartmental disposition of intravenous ammonia N-13 in the myocardium. In this model, the value of the rate constant, which represents the delivery of blood to myocardium, and the fraction of ammonia N-13 extracted into the myocardial cells, is a measure of myocardial blood flow. Optimal PET imaging of the myocardium is generally achieved between 10 to 20 minutes after administration.

12.3 Pharmacokinetics
Following intravenous injection, Ammonia N-13 Injection, USP is cleared from the blood with a biologic half-life of about 2.84 minutes (effective half-life of about 2.21 minutes). In the myocardium, its biologic half-life has been estimated to be less than 2 minutes (effective half-life less than 1.67 minutes).

The mass dose of Ammonia N-13 Injection, USP is very small as compared to the normal range of ammonia in the blood (0.72-3.30 mg) in a healthy adult man [see Description (11.1)]. Plasma protein binding of ammonia N-13 or its N-13 metabolites has not been studied.

Ammonia N-13 undergoes a five-enzyme step metabolism in the liver to yield urea N-13 (the main circulating metabolite). It is also metabolized to glutamine N-13 (the main metabolite in tissues) by glutamine synthesis in the skeletal muscles, liver, brain, myocardium, and other organs. Other metabolites of ammonia N-13 include small amounts of N-13 amino acid anions (acidic amino acids) in the forms of glutamate N-13 or aspartate N-13.

Ammonia N-13 is eliminated from the body by urinary excretion mainly as urea N-13. The pharmacokinetics of Ammonia N-13 Injection, USP have not been studied in renally impaired, hepatically impaired, or pediatric patients.

13 NONCLINICAL TOXICOLOGY

13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility
Long term animal studies have not been performed to evaluate the carcinogenic potential of Ammonia N-13 Injection, USP. Genotoxicity assays and impairments of male and female fertility studies with Ammonia N-13 Injection, USP have not been performed.

14 CLINICAL STUDIES
In a descriptive, prospective, blinded image interpretation study of adult patients with known or suspected coronary artery disease, myocardial perfusion deficits in stress and rest PET images obtained with Ammonia N-13 (N=111 or Rubidium 82 (N=82) were compared to changes in stress/rest blood flow reserve (SFR) as determined by coronary angiography. The principal outcome of the study was the evaluation of PET defect severity relative to SFR.

PET perfusion defects at rest and stress for seven cardiac regions (anterior, apical, anterosventral, posteroseptal, anterolateral, posterolateral, and inferior walls) were graded on a 0 to 5 scale defined as normal (0), possible (1), probable (2), mild (3), moderate (4), and severe (5) defects. Coronary angiograms were used to measure absolute and relative stenosis dimensions and to calculate stenosis flow reserve defined as the maximum value of flow at maximum coronary vasodilatation relative to rest flow under standardized hemodynamic conditions. SFR scores ranged from 0 (total occlusion) to 5 (normal).

With increasing impairment of flow reserve, the subjective PET defect severity increased. A PET defect score of 2 or higher was positively correlated with flow reserve impairment (SFR<3).

15 REFERENCES

16 HOW SUPPLIED/STORAGE AND HANDLING
Ammonia N-13 Injection, USP is packaged in 10 mL multiple dose glass vial containing between 1.11-1.11 GBq (30-300 mCi) of [13N] ammonia, at the end of synthesis (EOS) reference time, in 0.9% sodium chloride injection solution in approximately 8 mL to 10 mL volume. The recommended dose of radioactivity (10-20 mCi) is associated with a theoretical mass dose of 0.5-1.0 picomoles of ammonia.

NDC 65857-200-10

Storage Store at 25°C (77°F), excursions permitted to 15-30°C (59-86°F). Use the solution within 60 minutes of the End of Synthesis (EOS) calibration.

17 PATIENT COUNSELLING INFORMATION

17.1 Pre-study Hydration
Instruct patients to drink plenty of water or other fluids (as indicated) in the 4 hours before their PET study.

17.2 Post-study Voidsing
Instruct patients to void after completion of each image acquisition session and as often as possible for one hour after the PET scan ends.

17.3 Post-study Breastfeeding Avoidance
Instruct nurses to substitute stored breast milk or infant formula for breast milk for 2 hours after administration of Ammonia N-13 Injection, USP.

Manufactured by: Cardinal Health 414, LLC 7000 Cardinal Place Dublin, OH 43017

Distributed by: Cardinal Health 414, LLC 7000 Cardinal Place Dublin, OH 43017

Revised: 06/2013

NPS-PF-0001 ver 2.0
### HIGHLIGHTS OF PRESCRIBING INFORMATION

**Caution** should be exercised and emergency equipment should be available when administer

**None known.**

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### DOSAGE FORMS AND STRENGTHS

**Technetium Tc 99m Sestamibi Injection.**

**HIGHLIGHTS OF PRESCRIBING INFORMATION**

**Use in specific populations (8.4)**

10/2007

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### 2 DOSAGE AND ADMINISTRATION

1. **Image Acquisition**

**Bread imaging:** Technetium Tc 99m Sestamibi Injection is indicated for planar imaging as a second line diagnostic tool after mammography to assist in the evaluation of breast lesions in patients with an abnormal mammogram or a palpable lesion.

**Bread imaging:** Technetium Tc 99m Sestamibi is indicated for planar imaging to assist in the evaluation of breast lesions in patients with an abnormal mammogram or a palpable lesion.

**Bread imaging:** Technetium Tc 99m Sestamibi is indicated for planar imaging to assist in the evaluation of breast lesions in patients with an abnormal mammogram or a palpable lesion.

**Breast imaging:** Technetium Tc 99m Sestamibi Injection is indicated for breast cancer screening, to confirm the presence or absence of malignancy, and it is not an alternative to biopsy.

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### 5 WARNINGS AND PRECAUTIONS

5. The **TLC plate diagram**

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### References

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### Contraindications

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### 4. Add 2 drops of Technetium Tc 99m Sestamibi solution, side by side on top of the

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### 2.2 Radiation Dosimetry

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### 2.1 Image Acquisition

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### 1.1 Clinical Characteristics

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### 1 INDICATIONS AND USAGE

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### 9.2 Abuse

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### 9.1 Controlled Substance

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### 8 USE IN SPECIFIC POPULATIONS

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### 2.2 Radiation Dosimetry

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### 2 Dosage and Administration

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### 3 Dosage Forms and Strengths

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### 3 CONTRAINDICATIONS

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### 6.1 Radiation Absorbed Doses from Tc 99m Sestamibi

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### Table 1: Radiation Absorbed Doses from Tc 99m Sestamibi

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### 3.5 Radiation Dose to Specific Organs

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### 2.2 Radiation Dosimetry

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### 1 INDICATIONS AND USAGE

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### 1 INDICATIONS AND USAGE

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### 2.1 Image Acquisition

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### 2.1 Image Acquisition

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### 2 Dosage and Administration

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### 3 Dosage Forms and Strengths

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### 7.5 cm

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### 3.3 Carcinogenesis, Mutagenesis, Impairment of Fertility

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### 3.2 Pharmacokinetics

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### 3.2 Pharmacokinetics

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### 3.3 Carcinogenesis, Mutagenesis, Impairment of Fertility

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### 3.2 Pharmacokinetics

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### 3.5 Radiation Dose to Specific Organs

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### 2.1 Image Acquisition

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### 2.1 Image Acquisition

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### 2 Dosage and Administration

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### 2.1 Image Acquisition

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### 2 Dosage and Administration

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### 2 Dosage and Administration
10 OBSERVATIONS
The clinical consequences of overcoming Technetium Tc 99m Sestamibi are not known. 11 DESCRIPTION
Each 2 mL of Technetium Tc 99m Sestamibi contains: 250 MBq (±5%) of technetium-99m (Cu(MIBI)) in 1.5 mL of saline solution. 

Lipid-soluble chromophores have been identified which form complexes with technetium-99m in vivo. 

Radiopeptide: 

\[
\text{Cu}^{60} \text{Cu}^{2+} + 3 \text{H}_{2}\text{O} \rightarrow \text{Cu}^{57} \text{Cu}^{2+} + 3 \text{OH}^{-} + \text{H}^{+}
\]

Prior to injection the pH is kept to 5.5 ± 0.5. The contents of the vial are syringed off and stored under nitrogen.

12 ADVERSE EVENTS
The agent is not known to produce any adverse effects. 

12.5 Elimination
The half-life of Technetium Tc 99m Sestamibi is approximately 200 minutes. 

13 CLINICAL STUDIES
13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility

No evidence of carcinogenic potential or teratogenicity has been shown in any experimental animal species. 

13.2 Reproduction

Data has been obtained in mice, rats, and rabbits, including three generations of matings at one-third of the maximum tolerated dose. 

13.3 Nursing Mothers

Technetium Tc 99m Sestamibi is excreted in human milk during lactation. It is not known whether the drug penetrates milk in significant amounts. 

13.4 Pediatric Use

Although no controlled studies have been performed on the use of Technetium Tc 99m Sestamibi in children, normal myocardial perfusion scans have been obtained in children ranging from birth to 17 years of age. 

14 REFERENCES

The references are in the form of cited authors and page numbers followed by the citation number(s) in parentheses. 

15 SOURCES

Abnormal angiogram and an abnormal Technetium Tc 99m Sestamibi scan. No clinically meaningful correlation of normal or abnormal perfusion scans and long term cardiac events was evaluated in 521 women (51 men, 10 women) with stable chest pain. There were 73% Caucasians, 25% Blacks, 2% Asian and 1.2% Native American. Mean age was 59.6 years (range: 32-84 years). All patients had a baseline study within 24 months. 

18 ADVERSE EFFECTS
Adverse effects were evaluated in 609 pediatric patients from the three clinical studies described above. 

19 NURSE’S DRUG INFORMATION

General
Technetium Tc 99m Sestamibi is a cardiac Tc 99m complex which has been found to accumulate in malignant and non-malignant conditions. 

25 DRUG ABUSE AND DEPENDENCE

Drug abuse and dependence on Technetium Tc 99m Sestamibi have not been observed. 

29 ADMINISTRATION

The major pathway for clearance of Tc 99m Sestamibi is the hepatobiliary system. Activity from the liver is approximately 30 minutes, after a rest or exercise injection. The ideal imaging time reflects the radiation emitted by this radionuclide that results from interposition of various thicknesses of Pb or other shielding materials. 

30 DESCRIPTION

Each 5 mL vial contains a sterile, non-pyrogenic, lyophilized mixture of: 

- Sodium Chloride, 9 g 
- Sodium Bicarbonate, 4 g 
- Sodium Lactate, 2.5 g 
- Glycine, 0.5 g 
- Calcium Chloride, 0.25 g 
- Magnesium Chloride, 0.25 g 
- Potassium Chloride, 0.25 g 
- Sodium Fluoride, 0.1 g 
- Sodium Metabisulfite, 0.05 g 

31 CLINICAL PHARMACOLOGY

General
Technetium Tc 99m Sestamibi is a cardiac Tc 99m complex which has been found to accumulate in malignant and non-malignant conditions. 

32 PHARMACOKINETICS

Pulmonary edema is negligible even immediately after injection. 

33 PHARMACODYNAMICS

Animal studies have shown that myocardial uptake is not blocked when the sodium pump mechanism is inhibited. Although studies of subcellular fractionation and electron micrographic analysis of heart cell aggregates suggest that Tc 99m Sestamibi cardiac retention occurs specifically within mitochondria as a result of electrostatic interactions, the clinical relevance of these findings has not been established. 

36 DISCUSSION

Myocardial retention which is currently flow dependent is 1.2% of the injected dose at rest and 1.5% of the injected dose at exercise. Table 5 illustrates the clinical behavior as well as efficacy. 

37 CLINICAL CONSIDERATIONS

The clinical consequences of overcoming Technetium Tc 99m Sestamibi are not known. 

38 OVERDOSAGE

The clinical consequences of overcoming Technetium Tc 99m Sestamibi are not known. 

39 DESCRIPTION

Each 2 mL of Technetium Tc 99m Sestamibi contains: 250 MBq (±5%) of technetium-99m (Cu(MIBI)) in 1.5 mL of saline solution. 

40 LIPID-SOLUBLE CHROMOPHORES

Radiopeptide: 

\[
\text{Cu}^{60} \text{Cu}^{2+} + 3 \text{H}_{2}\text{O} \rightarrow \text{Cu}^{57} \text{Cu}^{2+} + 3 \text{OH}^{-} + \text{H}^{+}
\]

Prior to injection the pH is kept to 5.5 ± 0.5. The contents of the vial are syringed off and stored under nitrogen.

41 ADVERSE EVENTS
The agent is not known to produce any adverse effects.

42 ADVERSE EVENTS
The agent is not known to produce any adverse effects.

43 CLINICAL STUDIES

In this trial as summarized in Table 7, 24/521 (4.6%) had a cardiac event. 

44 ADMINISTRATION

Technetium Tc 99m Sestamibi was administered by intravenous push through a 1 mL syringe containing approximately 2 mL of the tracer. 

45 DESCRIPTION

Each 5 mL vial contains a sterile, non-pyrogenic, lyophilized mixture of: 

- Sodium Chloride, 9 g 
- Sodium Bicarbonate, 4 g 
- Sodium Lactate, 2.5 g 
- Glycine, 0.5 g 
- Calcium Chloride, 0.25 g 
- Sodium Metabisulfite, 0.05 g 
- Sodium Fluoride, 0.1 g 
- Sodium Metabisulfite, 0.05 g 

46 CLINICAL PHARMACOLOGY

General
Technetium Tc 99m Sestamibi is a cardiac Tc 99m complex which has been found to accumulate in malignant and non-malignant conditions. 

47 PHARMACOKINETICS

Pulmonary edema is negligible even immediately after injection. 

48 PHARMACODYNAMICS

Animal studies have shown that myocardial uptake is not blocked when the sodium pump mechanism is inhibited. Although studies of subcellular fractionation and electron micrographic analysis of heart cell aggregates suggest that Tc 99m Sestamibi cardiac retention occurs specifically within mitochondria as a result of electrostatic interactions, the clinical relevance of these findings has not been established. 

49 DISCUSSION

Myocardial retention which is currently flow dependent is 1.2% of the injected dose at rest and 1.5% of the injected dose at exercise. Table 5 illustrates the clinical behavior as well as efficacy. 

50 CLINICAL CONSIDERATIONS

The clinical consequences of overcoming Technetium Tc 99m Sestamibi are not known.
Sodium Fluoride F-18 Injection, USP

For Intravenous Use

Initial U.S. Approval: 2011

---

**INDICATIONS AND USAGE**

- Sodium Fluoride F-18 Injection, USP, is a radioactive diagnostic agent for positron emission tomography (PET) imaging of bone to define areas of altered osteogenic activity (1).

---

**DOSEAGE AND ADMINISTRATION**

- Sodium Fluoride F-18 Injection, USP, emits radiation and must be handled with appropriate safety measures (2).  
  - Administer 301-450 MBq (8-12 mCi) as an intravenous injection in adults (2.4).  
  - Administer approximately 1.5 MBq/kg in children with a minimum of 19 MBq (0.5 mCi) and a maximum of 148 MBq (4 mCi) as an intravenous injection (2.5).  
- Imaging can begin 1-2 hours after administration; optimally at one hour post administration (2.7).  
- Encourage patients to void immediately prior to imaging the lumbar spine and bony pelvis (2.7).

---

**DOSAGE FORMS AND STRENGTHS**

Multi-dose vial containing 370-740 MBq/mL (10-200 mCi/mL) of no-carrier-added sodium fluoride F-18 at the end of synthesis (EOS) reference time in aqueous 0.9% sodium chloride solution (3).

---

**FULL PRESCRIBING INFORMATION: CONTENTS**

1 INDICATIONS AND USAGE  
2 DOSAGE AND ADMINISTRATION  
3 DOSAGE FORMS AND STRENGTHS  
4 CONTRAINDICATIONS  
5 WARNINGS AND PRECAUTIONS  
6 ADVERSE REACTIONS  
7 DRUG INTERACTIONS  
8 USE IN SPECIFIC POPULATIONS  
9 Pregnancy  
10 Nursing Mothers  
11 DESCRIPTION  
12 CLINICAL PHARMACOLOGY  
13 NONCLINICAL TOXICOLOGY  
14 CLINICAL STUDIES  
15 REFERENCES  
16 HOW SUPPLIED/STORAGE AND HANDLING  
17 PATIENT COUNSELING INFORMATION  
18 8.4 Pediatric Use  
19 11.1 Chemical Characteristics  
20 11.2 Physical Characteristics  
21 12.1 Mechanism of Action  
22 12.2 Pharmacodynamics  
23 12.3 Pharmacokinetics  
24 13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility  
25 14.1 Metastatic Bone Disease  
26 14.2 Other Bone Disorders  
27 16.1 HOW SUPPLIED/STORAGE AND HANDLING  
28 16.2 STORAGE AND HANDLING  
29 17.1 Pre-Study Hydration  
30 17.2 Post-Study Voiding

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**ADVERSE REACTIONS**

No adverse reactions have been reported for Sodium Fluoride F-18 Injection, USP, based on a review of the published literature, publicly available reference sources, and adverse drug reaction reporting systems (6).

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**CONTRAINDICATIONS**

None (4).

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**WARNINGS AND PRECAUTIONS**

- Allergic Reactions: As with any injectable drug product, allergic reactions and anaphylaxis may occur. Emergency resuscitation equipment and personnel should be immediately available (5.1).
- Nursing: A decision should be made whether to interrupt nursing after Sodium Fluoride F-18 Injection, USP, administration or not to administer Sodium Fluoride F-18 Injection, USP, taking into consideration the importance of the drug to the mother (8.3).
- Pediatrics: Children are more sensitive to radiation and may be at higher risk of cancer from Sodium Fluoride F-18 Injection, USP (8.4).

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**CLINICAL STUDIES**

To report SUSPECTED ADVERSE REACTIONS, contact Cardinal Health at 1-800-618-2768 or FDA at 1-800-FDA-1088 or www.fda.gov/medwatch

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**PHARMACOKINETICS**

See full prescribing information for Sodium Fluoride F-18 Injection, USP, safely and effectively. See full prescribing information for Sodium Fluoride F-18 Injection, USP.

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**THERAPEUTIC EFFICACY**

For Intravenous Use

Sodium Fluoride F-18 Injection, USP, is a radioactive diagnostic agent for positron emission tomography (PET) imaging of bone to define areas of altered osteogenic activity (1).
2.7 Imaging Guidelines
- Imaging of Sodium Fluoride F-18 Injection, USP, can begin 1–2 hours after administration; optimally at 1 hour post administration.
- Encourage the patient to void immediately prior to imaging the fluorode F-18 radioactivity in the lumbar spine or bony pelvis.

3 DOSAGE FORMS AND STRENGTHS
Multiple-dose vials containing 370–7,400 MBq (10–200 mCi/ml) at EOS reference time of no-carrier-added sodium fluoride F-18 and 0.9% sodium chloride solution. Sodium Fluoride F-18 Injection, USP, is a clear, colorless, sterile, pyrogen-free and preservative-free solution for intravenous administration.

4 CONTRAINDICATIONS
None

5 WARNINGS AND PRECAUTIONS
5.1 Allergie Reactions
As with any injectable drug product, allergic reactions and anaphylaxis may occur. Emergency resuscitation equipment and personnel should be immediately available.

5.2 Radiation Risks
Sodium Fluoride F-18 Injection, USP, may increase the risk of cancer. Carcinogenic and mutagenic studies with Sodium Fluoride F-18 Injection, USP, have not been performed. Use the smallest dose necessary for imaging and ensure safe handling to protect the patient and health care worker [see Dosage and Administration (2.1)].

6 ADVERSE REACTIONS
No adverse reactions have been reported for Sodium Fluoride F-18 Injection, USP, based on a review of the published literature, publicly available reference sources, and adverse drug reaction reporting systems. However, the completeness of these sources is not known.

7 DRUG INTERACTIONS
The possibility of interactions of Sodium Fluoride F-18 Injection, USP, with other drugs taken by patients undergoing PET imaging has not been studied.

8 USE IN SPECIFIC POPULATIONS
8.1 Pregnancy
Pregnancy Category C
Any radiopharmaceutical including Sodium Fluoride F-18 Injection, USP, has a potential to cause fetal harm. The likelihood of fetal harm depends on the stage of fetal development, and the radiolabeled dose. Animal reproductive and developmental toxicity studies have not been conducted with Sodium Fluoride F-18 Injection, USP. Prior to the administration of Sodium Fluoride F-18 Injection, USP, to women of childbearing potential, assess for presence of pregnancy. Sodium Fluoride F-18 Injection, USP, should be given to a pregnant woman only if clearly needed.

8.3 Nursing Mothers
It is not known whether Sodium Fluoride F-18 Injection, USP, is excreted into human milk. Because many drugs are excreted in human milk and because of the potential for serious adverse reactions in nursing infants, a decision should be made whether to interrupt nursing or to discontinue the use of the drug. The mother should be informed about the potential effect of this drug on the nursing infant.

8.4 Pediatric Use
In reported clinical experience in approximately 100 children, weight based doses (2.1 MBq/kg) ranging from 19 MBq–148 MBq (0.5 mCi–4 mCi) were used. Sodium Fluoride F-18 was shown to localize to areas of bone turnover including rapidly growing epiphyses in developing long bones. Children are more sensitive to radiation and may be at higher risk of cancer from Sodium Fluoride F-18 Injection, USP.

11 DESCRIPTION
11.1 Chemical Characteristics
Sodium Fluoride F-18 Injection, USP, is a positron emitting radiopharmaceutical, containing no-carrier-added, radioactive fluoride F-18 that is used for diagnostic purposes in conjunction with PET imaging. It is administered by intravenous injection. The active ingredient, sodium fluoride F-18, has the molecular formula Na[18F] with a molecular weight of 40.99, and has the following chemical structure: Na[18F].

Sodium Fluoride F-18 Injection, USP, is provided as a ready-to-use, isotonic, sterile, pyrogen-free, and preservative-free solution for intravenous administration. Sodium Fluoride F-18 Injection, USP, is a clear, colorless, sterile, pyrogen-free and preservative-free solution for intravenous administration.

11.2 Physical Characteristics
Fluoride F-18 decays by positron (β+)-emission and has a half-life of 109.7 minutes. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV.

12 CLINICAL PHARMACOLOGY
12.1 Mechanism of Action
Fluoride F-18 ion normally accumulates in the skeleton in an even fashion, with greater deposition in the anterior skeleton (femora and pelvis) than in the appendicular skeleton and greater deposition in the bones around joints than in the shafts of long bones.

12.2 Pharmacodynamics
Increased fluoride F-18 ion deposition in bone can occur in areas of increased osteogenic activity during growth, infection, malignancy (primary or metastatic) following trauma, or inflammation of bone.

13 NONCLINICAL TOXICOLOGY
13.1 Carcinogenesis, Mutagenesis, Impairment of Fertility
Studies to assess reproductive toxicity, mutagenesis and carcinogenic potential of Sodium Fluoride F-18 Injection, USP, have not been performed.

14 CLINICAL STUDIES
14.1 Metastatic Bone Disease
The dosages used in reported studies ranged from 2.7 MBq (100 MBq) to 740 MBq (20 MBq) with an average median dose of 107 MBq (370 MBq) and an average mean dose of 9.2 MBq (140 MBq). In PET imaging of bone metastases with Sodium Fluoride F-18 Injection, USP, locally increased tracer uptake is seen in both osteolytic and osteoblastic bone lesions. Negative PET imaging results with Sodium Fluoride F-18 Injection, USP, do not preclude the diagnosis of bone metastases. Also, as benign bone lesions are also detected by Sodium Fluoride F-18 Injection, USP, positive PET imaging results cannot replace biopsy to confirm a diagnosis of cancer.

14.2 Other Bone Disorders
The dosages used in reported studies ranged from 2.43 MBq (15 miC) to 15 MBq (955 MBq), with an average median dose of 8.0 MBq (380 MBq) and an average mean dose of 7.6 MBq (280 MBq).

15 WARNINGS AND PRECAUTIONS
15.1 Stability
Sodium Fluoride F-18 Injection, USP, is a positron emitting radiopharmaceutical which decays by positron emission. The radionuclide has a half-life of 109.7 minutes. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV. Ninety-seven percent of the decay results in emission of a positron with a maximum energy of 0.63 MeV and 3% of the decay results in emission of a positron with a maximum energy of 4.4 MeV.

15.2 Radiation Dose Calculation
The time since calibration is multiplied by the fraction remaining at that time to obtain the fraction remaining at the present time. This fraction may be used to correct for physical decay of the radionuclide.

16 HOW SUPPLIED/STORAGE AND HANDLING
Sodium Fluoride F-18 Injection, USP, is supplied in a multiple-dose Type I glass vial with elastomeric stopper and aluminum crimp seal containing between 370 and 7,400 MBq (10–200 mCi) of no-carrier-added sodium fluoride F-18, at the EOS reference time, in aqueous 0.9% sodium chloride solution. The total volume and total radioactivity per vial are variable. Each vial is enclosed in a shielded container of appropriate thickness.

17 PATIENT COUNSELING INFORMATION
17.1 Pre-Study Hydration
Encourage patients to drink at least 500 mL of water prior to drug administration.

17.2 Post-Study Voiding
To help protect themselves and others in their environment, patients should take the following precautions for 12 hours after injection: whenever possible, use a toilet and flush several times after each use; wash hands thoroughly after each voiding or fecal elimination. If blood, urine or feces soil clothing, wash the clothing separately.

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